



Faculty of Engineering

**RISK ASSESSMENT FOR RIVER TRANSPORT:
KUCHING EXPRESS BOAT PASSENGER TERMINAL
(MAINTENANCE & UTILIZATION)**

FRANKLIN SIMON

Bachelor of Engineering with Honours
(Civil Engineering)
2010

**RISK ASSESSMENT FOR RIVER TRANSPORT:
KUCHING EXPRESS BOAT PASSENGER TERMINAL
(MAINTENANCE & UTILIZATION)**

FRANKLIN SIMON

This thesis is submitted to Faculty of Engineering, Universiti Malaysia Sarawak
in partial fulfillment of the requirement for the Degree of Bachelor of
Engineering with Honours (Civil Engineering)

2010

UNIVERSITI MALAYSIA SARAWAK

THESIS STATUS ENDORSEMENT FORM

TITLE RISK ASSESSMENT FOR RIVER TRANSPORT: KUCHING EXPRESS BOAT PASSENGER TERMINAL
(MAINTENANCE & UTILIZATION)

ACADEMIC SESSION : 2009/2010

I FRANKLIN SIMON

(CAPITAL LETTERS)

Hereby agree that this Thesis* shall be kept at the Centre for Academic Information Services, Universiti Malaysia Sarawak, subject to the following terms and conditions:

1. The Thesis is solely owned by Universiti Malaysia Sarawak
2. The Centre for Academic Information Services is given full rights to produce copies for educational purposes only
3. The Centre for Academic Information Service is given full rights to do digitization in order to develop local content database
4. The Centre for Academic Information Services is given full rights to produce copies of this Thesis as part of its exchange item program between Higher Learning Institutions [or for the purpose of interlibrary loan between HLI]
5. ** Please tick (✓)

☐ CONFIDENTIAL (Contains classified information bounded by the OFFICIAL SECRETS ACT 1972)

☐ RESTRICTED (Contains restricted information as dictated by the body or organization where the research was conducted)

☒ UNRESTRICTED

Validated by

FRANKLIN SIMON (AUTHOR)

MR. RON ALDRINO CHAN
(SUPERVISOR)

Permanent Address

LOT 223, NO. 1491, LRG E-5B,
TMN SATRIA JAYA BDC,
93350, KUCHING, SARAWAK.

Date: _____

Date: _____

Notes * Thesis refers to PhD, Master and Bachelor Degree

** For Confidential or Restricted materials, please attach relevant documents from relevant organizations/ authorities

Supervisor's Letter of Declaration

The following Final Year Project Report:

Title : Risk assessment for river transport: Kuching Express Boat
Passenger Terminal (Maintenance & Utilization)
Name of Author : Franklin Simon
Student ID : 16254

Has been read and approved by:

Mr Ron Aldrino Chan @ Ron Biking
Supervisor

Date

Laporan Projek Tahun Akhir berikut:

Tajuk: Risk assessment for river transport: Kuching Express Boat Passenger Terminal
(Maintenance & Utilization)

Nama Penulis: Franklin Simon

Matrik: 16254

Telah dibaca dan disahkan oleh:

Mr Ron Aldrino Chan @ Ron Buking
Penyelia

Tarikh

This thesis is dedicated to my beloved father and mother,
who have taught me that best kind of knowledge
to have is that which is learned for its own sake

ACKNOWLEDGEMENTS

I would like to express my deepest gratitude to my supervisor, Mr. Ron Aldrino Chan @ Ron Buning for his wise advice, constructive criticisms and patient encouragement which have enabled me to write this thesis in innumerable ways. I would also like to express my thanks to Ir. Ting Sim Nee, my co-supervisor who have assisted and shared her vast knowledge for my thesis construction.

To Mr. Tay Kai Meng, who have assisted me greatly in this thesis writing. His expertise, knowledge and patience have successfully aided me in many ways.

A heartfelt gratitude I express to Mr. Christopher Chan (Senior Assistant Controller) and Mr. Mohammad Fadzli Hj Noh (Port Assistant Manager) of Sarawak Rivers Board for all their co-operation and assistance. I would also like to acknowledge my appreciation to the Sarawak Rivers Board authorities for their participation in making this thesis successful.

Lastly, thank you to everyone else who have directly or indirectly assisted in the writing of this thesis.

ABSTRAK

Pembangunan sistem pengangkutan air di Sarawak, Malaysia masih dianggap berada pada peringkat awal. Terdapat kemungkinan bahawa sistem pengangkutan air di Sarawak boleh dipertingkatkan dan dijadikan salah satu penyumbang untuk menaik tarafkan sistem pengangkutan air dalam negeri ini. Terminal Penumpang Bot Ekspres Kuching, Lembaga Sungai-Sungai Sarawak merupakan sasaran utama dalam kajian ini. Kajian ini melibatkan penilaian risiko kualitatif dan kuantitatif terhadap penyenggaraan dan penggunaan terminal. Kajian ini dijangka akan menyumbang kepada pembangunan industri sistem pengangkutan air di Sarawak. Pengedaran soalan-soalan survei untuk tujuan penilaian risiko kualitatif dan satu kaedah yang dikenali sebagai *Fuzzy Failure Mode dan Effect Analysis (FMEA)* telah diadaptasikan untuk menjalankan penialain risiko kuantitatif terminal tersebut. Jadual kedudukan skala pengkadaran untuk keterukan, peristiwa dan pengesanan telah digunakan untuk menjalankan kaedah *fuzzy FMEA*. Daripada analisa yang telah dijalankan, nilai *fuzzy risk priority number (RPN)* tertinggi telah diperolehi daripada komponen rakit-rakit keselamatan (351, 323 sekiranya ternormal) dan nilai *fuzzy RPN* terendah pula didapati daripada komponen pagar-pagar (83.9, 5 sekiranya ternormal). Rakit-rakit keselamatan telah ditarafkan sebagai tertinggi dan pagar-pagar pula ditarafkan sebagai terendah dalam kedudukan nilai *fuzzy RPN*. Walaubagaimanapun, nilai-nilai yang telah diperolehi daripada kaedah ini didapati tidak menyokong nilai teori disebabkan beberapa kelemahan-kelemahan seperti wujudnya ‘lubang-lubang’ dalam fungsi-fungsi keahlian. Peningkatan pada masa depan melibatkan kaedah ini adalah seperti pengubahsuaian jadual kedudukan skala pengkadaran supaya kaedah ini dapat disesuaikan untuk menjalankan penilaian risiko

terhadap mana-mana infrastruktur sungai. Kesimpulannya, kaedah *fuzzy FMEA* ini telah dibuktikan dapat diaplikasikan dalam penilaian risiko sesebuah infrastruktur sungai dari segi penyenggaraan and penggunaan.

ABSTRACT

The development of water transport in Sarawak, Malaysia is considered to be in the early stages. There are possibilities that the water transport system in Sarawak can be improved and made a contributor to enhancing the public transportation system in the state. The Sarawak Rivers Board, Kuching Express Boat Passenger Terminal was the targeted area of study. This study focused on the conducting of qualitative and quantitative risk assessment on the maintenance and utilization of the passenger terminal. Such studies have yet to be performed in the state. Therefore, this study will benefit the development of the water transport industry in Sarawak. Distribution of survey questionnaires were carried out for the qualitative risk assessment while a method known as the Fuzzy Failure Mode and Effect Analysis (FMEA) has been adopted for the quantitative risk assessment. Furthermore, scale ranking table of ratings for severity, occurrence and detect were used to carry out the fuzzy FMEA method. Results obtained from the fuzzy FMEA method were in the form of fuzzy RPN number, which are the products of severity, occurrence and detect. From the analysis, life rafts have the highest fuzzy RPN at 351 (323 if normalized) while the lowest fuzzy RPN was obtained from railings (83.9, 5 if normalized). Life rafts were rated highest while railings were rated lowest in the fuzzy RPN number rankings. However, values obtained from the method were not as projected theoretically due to its shortcomings, such as existence of loop holes in membership functions. Future improvements of the method may include the modification of the scale tables to suit better risk assessment for any river infrastructure. In conclusion, the fuzzy FMEA method was proven to be applicable in conducting risk assessment on a river infrastructure in terms of maintenance and utilization.

LIST OF TABLES

Table	Page
3.1 Scale table for severity	64
3.2 Scale table for occurrence	64
3.3 Scale table for detect	65
4.1 Experts' Meeting Form	69
4.2 Normalized fuzzy RPN numbers	76
4.3 Mean Rating for survey Questionnaires	78

LIST OF FIGURES

Figure	Page
1.1 Sarawak Rivers Board, Kuching Express Boat Passenger Terminal frontal view	5
1.2 Passenger terminal waiting area	6
1.3 The concrete walkway, connected to the gangway	6
2.1 Literature Review Cycle Diagram	10
2.2 The traditional FMEA procedure (Tay & Lim, 2006)	39
2.3 FMEA with Fuzzy RPN model (Tay & Lim, 2006)	42
2.4 A fuzzy reasoning risk analysis system (Tay & Lim, 2006)	44
2.5 Conceptual Research frameworks (Nguyen <i>et al.</i> , 2008)	47
2.6 Risk control Short term and Long term grading (Ridley, 1994)	49
3.1 The Fuzzy FMEA procedure (Tay & Lim, 2006)	58
3.2 Steps in methodology	59
4.1 Triangular Membership Function for Severity	73
4.2 Triangular Membership Function for Occurrence	73

4.3	Triangular Membership Function for Detect	74
4.4	Triangular Membership Function for Fuzzy RPN number	74
4.5	Respondents, by Age Group, in Years (Percentage)	80
4.6	Main Activity of Respondents at the express terminal (Percentage)	81
4.7	Pontoons: Safety (Risk percentage)	83
4.8	Pontoons: Safety (Risk Rating)	83
4.9	Pontoons: Maintenance (Risk percentage)	84
4.10	Pontoons: Maintenance (Risk Rating)	85
4.11	Railings: Safety (Risk percentage)	86
4.12	Railings: Safety (Risk Rating)	86
4.13	Railings: Maintenance (Risk percentage)	87
4.14	Railings: Maintenance (Risk rating)	88
4.15	Walkway: Safety (Risk Rating)	89
4.16	Walkway: Maintenance (Risk percentage)	90
4.17	Walkway: Maintenance (Risk Rating)	90
4.18	Public Washroom: Maintenance (Risk percentage)	92
4.19	Public Washroom: Maintenance (Risk Rating)	92
4.20	Life jackets: Safety (Risk Percentage)	94
4.21	Life jackets: Safety (Risk Rating)	94
4.22	Life Jackets: Maintenance (Risk Percentage)	95

4.23	Life Jackets: Maintenance (Risk Rating)	96
4.24	Life Buoys: Safety (Risk Percentage)	97
4.25	Life Buoys: Safety (Risk Rating)	97
4.26	Life Buoys: Maintenance (Risk Percentage)	98
4.27	Life Buoys: Maintenance (Risk Rating)	99
4.28	Life Rafts: Safety (Risk Rating)	100
4.29	Life Rafts: Maintenance (Risk Percentage)	101
4.30	Life Rafts: maintenance (Risk Rating)	101
5.1	Surface: Severity vs Detect	109
5.2	Surface: Severity vs Occurrence	109
5.3	Surface: Occurrence vs Detect	110
5.4	Surface: Severity	110
5.5	Surface: Occurrence	111
5.6	Surface: Detect	111

LIST OF ABBREVIATIONS

BBN	-	Bayesian belief networks
D		Detect
EMV	-	Expected monetary value
FIS	-	Fuzzy Inference System
FMEA	-	Failure Mode and Effect Analysis
IWT	-	Inland Waterway Transport
JSA	-	Job Safety Analysis
MF	-	membership functions
O		Occurrence
RL	-	risk levels
RPN	-	risk priority number
S		Severity
SRB	-	Sarawak Rivers Board
SWOT	-	Strengths, Weakness, Opportunities and Threats
TriMF	-	Triangular membership functions
UNDP	-	United Nations Development Programme

TABLE OF CONTENTS

	Page
Acknowledgement	ii
Abstrak	iii
Abstract	v
List of Tables	xii
List of Figures	xiii
List of Abbreviations	xvi
Chapter 1 INTRODUCTION	
1.1 Introduction	1
1.2 Problem Statement	3
1.3 Aim and Objective of the Study	4
1.4 Scope of Research	5
1.5 Significance of the Study	7
1.6 Potential benefits	8
1.7 Chapter Conclusion	8
1.8 Brief Outline of Each Chapter	9
Chapter 2 LITERATURE REVIEW	
2.1 Literature Review Cycle Diagram	10
2.2 Risk Definition	11
2.3 Risk Management	12
2.4 Risk and Hazards Identification	14
2.4.1 Workplace Inspections	18
2.4.2 Management/Worker Discussion	19
2.4.3 Independent Audits	19
2.4.4 Job Safety Analysis	21
2.4.5 Hazard and Operability Studies	21
2.4.6 Accident Statistics	22

2.5	Risk Assessment	22
2.5.1	Significance of Risk Assessment in this Study	23
2.5.2	Risk Assessment Methods	23
2.5.2.1	Decide who might be harmed and how	24
2.5.2.2	Evaluate the risk and decide on precautions	25
2.5.2.3	Record findings and evaluating them	26
2.5.2.4	Review assessment and updating when necessary	27
2.5.3	Qualitative Risk Analysis	28
2.5.3.1	Risk probability and impact assessment	29
2.5.3.2	Probability and impact matrix	29
2.5.3.3	Risk data and qualitative assessment	30
2.5.3.4	Risk categorization	31
2.5.3.5	Risk urgency assessment	31
2.5.4	Quantitative Risk Analysis	31
2.5.4.1	Data gathering and representation techniques	33
2.5.4.2	Quantitative risk analysis and modeling techniques	33
2.5.5	Risk Assessment Models	35
2.5.5.1	Failure Mode and Effect Analysis (FMEA)	35
2.5.5.2	Traditional RPN model	37
2.5.5.3	Fuzzy FMEA model	40
2.5.5.4	Fuzzy inference System (FIS)	43

	2.5.5.5 Bayesian Belief Networks	45
2.6	Risk Control Strategies	48
	2.6.1 Risk Avoidance	49
	2.6.2 Risk Retention	50
	2.6.2.1 Risk retention with knowledge	50
	2.6.2.2 Risk retention without knowledge	51
	2.6.3 Risk Transfer	51
	2.6.4 Risk Reduction	52
2.7	Chapter Conclusion	53
Chapter 3	METHODOLOGY	
3.1	Introduction	55
3.2	Study Process	55
3.3	Determining the Research Objectives	56
3.4	Steps in Methodology	57
	3.4.1 Adopted Risk Assessment Model	57
	3.4.2 Conceptualization	60
	3.4.3 Literature Review	60
	3.4.4 Qualitative Assessment: Survey Questionnaires	61
	3.4.5 Quantitative Assessment: FMEA Approach	61
	3.4.6 Data Collection	62
	3.4.6.1 Scale tables for FMEA methodology	62
	3.4.7 Discussion	65
	3.4.8 Conclusion	66
3.5	Chapter Conclusion	66

Chapter 4	RESULTS & DATA ANALYSIS	
4.1	Introduction	67
4.2	Quantitative Risk Assessment: FMEA Approach	67
4.2.1	Experts' Meeting Results	68
4.2.2	Normalization of Fuzzy RPN	75
4.3	Qualitative Risk Assessment: Survey Questionnaires	77
4.3.1	Survey Questionnaire Data Analysis	79
4.3.2	Demographics	79
4.3.2.1	Respondents, by Age Group, in Years (Percentage)	80
4.3.2.2	Respondents, by Gender and Occupation (Percentage)	81
4.3.2.3	Main Activity of Respondents at the Passenger Terminal (Percentage)	81
4.3.3	Pontoons	82
4.3.3.1	Pontoons: Safety	83
4.3.3.2	Pontoons: Maintenance	84
4.3.4	Railings	85
4.3.4.1	Railings: Safety	86
4.3.4.2	Railings: Maintenance	87
4.3.5	Walkway	88
4.3.5.1	Walkway: Safety	89
4.3.5.2	Walkway: Maintenance	90
4.3.6	Public washroom	91
4.3.6.1	Public washroom: Maintenance	92

4.3.7 Life Jackets	93
4.3.7.1 Life Jackets: Safety	94
4.3.7.2 Life Jackets: Maintenance	95
4.3.8 Life Buoys	96
4.3.8.1 Life Buoys: Safety	97
4.3.8.2 Life Buoys: Maintenance	98
4.3.9 Life Rafts	99
4.3.9.1 Life Rafts: Safety	100
4.3.9.2 Life Rafts: Maintenance	101
4.4 Chapter Conclusion	102
 Chapter 5 DISCUSSION	
5.1 Introduction	103
5.2 Quantitative Risk Assessment: Experts' Meeting and Fuzzy FMEA method	103
5.2.1 Fuzzy FMEA	104
5.2.2 Problems with Fuzzy FMEA	107
5.3 Qualitative Risk Assessment: Survey Questionnaires	112
5.3.1 Demographics	113
5.3.2 Pontoons	113
5.3.3 Railings	114
5.3.4 Walkway	114
5.3.5 Public Washroom	115
5.3.6 Life Jackets	115
5.3.7 Life Buoys	116
5.3.8 Life Rafts	116
5.4 Chapter Conclusion	116

Chapter 6	CONCLUSION & RECOMMENDATIONS	
6.1	Introduction	118
6.2	Conclusion	118
6.3	Recommendations	120
	 BIBLIOGRAPHY/REFERENCES	 121
	APPENDICES	124

CHAPTER 5

DISCUSSION

5.1 Introduction

The focus of this chapter was to discuss data and results from Chapter 4. Two sections inclusive of the quantitative risk assessment and qualitative risk assessment were shown in this chapter. Discussions were carried out on the results and data from Experts' Meetings and distribution of survey questionnaires.

5.2 Quantitative Risk Assessment: Experts' Meeting and Fuzzy FMEA method

The Experts' Meeting was formed for the purpose of this study to conduct risk assessment on the Sarawak Rivers Board, Kuching Express Boat Passenger Terminal. Accordingly, the experts involved were identified as all officers and qualified staff members of Sarawak Rivers Board who are also directly involved in the day to day running of the passenger terminal. Additionally, they have adequate

knowledge and experience to fulfill the requirements for the Experts' Meeting and FMEA methodology. From the Experts' Meeting, 8 components were being studied including pontoons, railings, walkway, gangway, life jackets, life buoys, life rafts and the public washroom. A set of value of severity (S), occurrence (O) and detect (D) were obtained for each of these components. Fuzzy FMEA method was chosen to analyze the results obtained from the Experts' Meeting by the help of MATLAB version 7.0.0.19920 (R14). Results from the Experts' Meeting were compared with respondents' response to survey questionnaires for study purposes.

5.2.1 Fuzzy FMEA

Fuzzy FMEA and other FMEA methods alike have already been carried out in past researches such as on a public bus system (Hwang *et al.*, 2000) or on a fishing vessel (Pillay & Wang, 2003). However, this method has yet to be applied for the study of risk assessment of an express boat terminal.

Tay & lim (2008) mentioned that the assessment and prioritization of failure risk are to be carried out on experts' knowledge. For this study, the experts' meeting has been conducted with the experts' knowledge to be considered the most important consideration in risk assessment. Determination of the 8 components to conduct risk assessment upon were carried out with respect to experts' knowledge. Furthermore, experts ranked the severity, occurrences and detection in accordance to their

experience and knowledge of managing and working at the express boat passenger terminal.

Several important factors that had to be determined from the Experts' Meeting were such as the potential failure, potential effect and potential cause of failure for each of the 8 components. Potential failure are for examples breaking, cracking or leakage of the components. Potential effect of the failure are the consequences of the failure to the users and depending on the severity of the risk it could prove harmful to users. Potential cause of failure refers to the source of failure whether it could occur from poor quality of the component or the component was not manage properly.

Since life rafts had the highest fuzzy RPN number, this component was ranked as the first or most high risk compared to other components. The severity of the risk of life rafts may include failure of inflating or there could be leakage on the raft. On the contrary, it was also known that risk is associated to hazard, which is a substance such as the life rafts that can cause harm as according to Ridley (1994). Insufficient quantity of life rafts may also be a very dangerous threat to users. This posed as a hazard to the users in times of emergency. Such hazard could be caused by inadequate inspection of rafts or there are simply not enough provided to accommodate maximum passenger capacity. If the results from the Experts' Meeting are compared with the results from the survey questionnaire, most respondents would rate the severity of life rafts failure to be at 6.579 (Moderate) at average compared to the experts rating of severity, which was rated at 8 (High). However, life rafts were considered to be medium risk (low-medium if normalized) as according to the fuzzy RPN result. Thus, it could be mentioned that both experts' and respondents'